REMARKS

Review and reconsideration on the merits are requested.

Applicants, in response to Supplemental Election/Restrictions, elect 5) sulfonated

polyphenylene sulfide. All claims read on the elected species.

Applicants first would like to comment in general on the Q value, then answer several

questions which the Examiner raised during a telephone interview concerning this application

and then comment upon the amendment to claim 5.

The Q Value

Reference Figs. 1 and 2 attached show CV curves observed by cyclic voltammetry

performed at a temperature of 20°C in the presence of a Reference Electrode (SCE) at a scanning

voltage from -0.1 V to +0.7 V using an apparatus for measuring the Q value of the membrane

electrode assembly as shown in Fig. 2 of the specification.

As can be seen, the polymer electrolyte membrane is tightly contacted with the catalytic

electrode (Reference Fig. 2), a peak is observed caused by an adsorption current for adsorbing

protons on Pt particles in the catalytic electrode and a reduction current for reducing platinum

oxide to platinum in the CV curve also occurs where the scanning voltage from -0.1 V to 0.0

corresponds to the adsorption of protons to Pt particles and the scanning voltage from 0.0 to +0.7

V corresponds to the transportation of protons from the reference electrode to the catalytic layer

(containing Pt particles) through the polymer electrolyte membrane. The tighter the adhesion

between the polymer electrolyte membrane and the catalytic electrode, the higher the peak in the

CV curve, i.e., the greater the amount of electric charge, whereby one sees an increase in the deposit of Pt and the generation of hydrogen gas.

Specifically, in the cyclic voltammetry, when the voltage is changed in a direction from plus (+) to minus (-), the following reaction at platinum particles on the electrode surface occurs:

$$Pt + H_2O \rightarrow PtO + H_2,$$
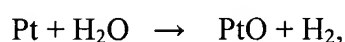
thereby forming PtO, which did not initially exist in the catalytic electrode. On the other hand, when the voltage is changed in a reverse fashion from minus (-) to plus (+), i.e., one carries out scanning at a voltage from -0.1 V to 0.7 V, the following reaction occurs in the catalytic electrode:

$$PtO + H_2 \rightarrow Pt + H_2O,$$
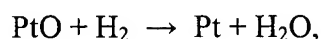
whereby reduction occurs with respect to PtO and a current flow can be observed. The amount of the current flow is measured, and the amount of the current flow per unit area of Pt on the electrode surface makes it possible to determine the total surface area of Pt on the electrode surface.

In this regard, the amount of the current flow varies with the concentration of aqueous sulfuric acid on a side free from electrode, and the higher the pH, the lower the peak observed. Specifically, a low proton concentration at a high pH value causes a decrease in the number of protons desorbed, and, accordingly, an electrolyte membrane electrode assembly is contacted

with an aqueous H_2SO_4 solution of pH = 1 (see Reference Fig. 3 enclosed herewith). Further, the

peak of the CV curve is found at 0.7 volt.

The presence of a nitrogen gas (inert gas) on the side of the electrode inhibits the reaction

of protonic H^+ with oxygen to form H_2O on the electrode surface.

The Telephone Interview

The Examiner raised a number of questions during the telephone interview conducted

regarding this application and it is believed that the following remarks respond to those

questions. If the undersigned has missed a question which the Examiner has, however, the

Examiner is requested to contact the undersigned and an attempt will be made to get further

information from the Inventors.

(1)   Q Value

With respect to the Q value, the Q value is principally the amount of electric charge per a

unit area determined by contacting an electrode side to a nitrogen as gas in a cell in which the

electrode is disposed on one side surface of a polymer electrode membrane and the other side

surface of said polymer electrode membrane is surrounded by an aqueous sulfuric acid solution

of pH1.

The Q value is also a parameter which shows the adhesion of an interface between a

catalytic electrode and a polymer electrolyte membrane in the membrane electrode assembly.

(2)   Catalyst Loading

Since the Q value is the amount of electric charge per a unit area determined from a peak

area of protons on an adsorption side with a scanning of voltage from -0.1 V to +0.7 V, the Q

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value is dependent on catalyst loading, and the Q value in the present invention is determined

when the amount of platinum particles in the catalytic layer of each electrode is 0.5 mg/cm^2. It

should be understood, of course, that in accordance with the present invention the catalyst

loading is not limited to 0.5 mg/cm^2, rather, that is simply the catalyst loading which is used to

measure the Q value. Thus, catalyst loadings greater than or less than 0.5 mg/^{2} are permissible.

(3)   Conditions required for the Q value

Since the Q value is the amount of electric charge per unit area, the transportation of

protons from the reference electrode to the catalytic layer (containing Pt particles) through the

polymer electrolyte membrane presumably influences the conditions required for the Q value.

Therefore, the most important factor influencing the Q value is the degree of adhesion between a

catalytic electrode and a polymer electrolyte membrane in the membrane electrode assembly. As

shown in Reference Fig. 1, in a state of poor adhesion therebetween, a peak is hardly observed in

the CV curve.

(4)   Other Miscellaneous/Secondary Factors in which can influence the Q value

Secondary factors which influence the Q value are factors which influence the number of

protons passing through the interface between the catalytic electrode and the polymer electrolyte

membrane in the membrane electrode assembly. These other factors seem to relate primarily to

the electrical conductivity thereof as follows.

Factors external to the polymer electrolyte membrane:

(1)   The pH value of aqueous H$_2$SO$_4$ solution; and

(2)   Temperature.

Factors internal to the polymer electrolyte membrane:

(1)   Polymer used;

(2)   Degree of sulfonation of the polymer used (having an ion exchange capacity

(milli-equivalent of the sulfonic group per 1 g) of 1-2.6 meq/g); and

Factors internal to the catalytic layer:

(3)   Polymer kind to be used as conductive binder,

(4)   Amount of the polymer used,

(5)   Amount of platinum particles (with particle size) contained,

(6)   Amount of carbon particles (with particle size) contained.

Applicants do wish to offer some comments on thickness. Thickness is a factor which

can affect the resistance of protons transporting from the polymer electrolyte membrane to the

catalytic layer. The present specification gives the dry thickness of the polymer electrolyte

membrane as being in the range of 20-60 μm.

It is believed that the above responds to the majority of the questions which the Examiner

raised.

With respect to whether the Q value is inherent to a polymer or not, see the above

discussion.

With respect to how one of ordinary skill in the art would know how to make a polymer

having a Q value which would fall in the claims, the Examiner is requested to note that

commercially available products can be used and quite clearly, one of ordinary skill in the art

would be able to synthesize polymers of a similar nature and subject such polymers to Q value

testing. The exact polymer used in the polymer electrolyte membrane electrode assembly of the present invention is not overly important, so long as it meets the criteria set forth in the present specification.

With respect to how the various materials are laminated during Q value testing, this is not believed to be an overly important factor in determining the Q value.

With respect to claim 5, which has now been amended to define the basic test procedure for determining the Q value and claim 18, which provides more detail if the Examiner finds claim 5 lacking, draft claim 5 sets out the basic Q value procedure the specification at the following points is relevant. Page 8, line 16, page 9, lines 1-2, page 11, lines 16-25, page 9, line 7 - page 10, line 16 and page 30, lines 14-21.

INTERVIEW SUMMARY

The Examiner did not seem to be overly concerned about the amendments to the specification creating a "new matter" problem. The Examiner did, however, take the basic position that it is unclear as to how a polymer electrolyte membrane (PEM) can be characterized by a Q value which, in the Examiner's view, is arbitrarily defined. The Examiner did not state that she would remove any "new matter" rejections, but the tone of the telephone interview was such that the point of greatest concern to the Examiner was the Examiner's view that the Q value was simply an arbitrarily defined factor which was dependent on so many factors that one of ordinary skill in the art would not be able to determine if any particular product would infringe claims which contain the Q value limitation.

One question which the Examiner asked is whether the Q value was inherent in a polymer or not.

A further question that the Examiner presented was how would one of ordinary skill in the art know how to make a polymer having a Q value which would fall within the claims? Commercially available products can be used and can be easily tested may to see if they have a Q value within the claims of the present application. Polymers analogous thereto can be synthesized and, the Q value simply measured as set forth in the specification.

The Examiner also questioned as to how one of ordinary skill in the art would make a PEM having a Q value within the claims? The earlier answer responds to this point.

The Examiner then raised a number of different questions, all of which seemed to arise from the Examiner's view that variables during Q value measurement could greatly affect the Q value results. For example, the Examiner asked:

Was the Q value just measured in a cell?

Is the Q value dependent on catalyst loading?

What conditions give the Q value?

Can the Q value change with conditions?

Is the Q value dependent on a number of factors external to the membrane?

During Q value testing, how are the various layers laminated?

Can the Q value change with conditions, i.e., is it dependent on external circumstances?

Although the primary purpose of the interview was to discuss the Q value problem, the Examiner did make the following remarks:

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The ranges in US 5,272,017 Swathirajan et al overlap with those of the present invention; and

Applicants, in response to Supplemental Election/Restrictions, elect 5) sulfonated polyphenylene sulfide. All claims read on the elected species. The Q value should be related to some membrane property.

With respect to US Patent 5,272,017 to Swathirajan et al. (applied against claims 1, 4 and 12), as stated in the Response to the Office Action (Amendment Under 37 C.F.R. § 1.111) dated June 7, 2004, at least amended claim 1 is not obvious over Swathirajan since Swathirajan does not teach or suggest any projection of the catalyst layer and any distance along the interface considering amended claim 1 of June 7, 2004. Applicants have now elected a single species 5) sulfonated polyphenylene sulfide for the sulfonated hydrocarbon polymers in amended claims 10 and 16. Swathirajan is silent regarding such materials.

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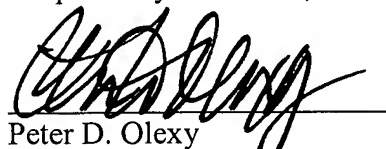
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